STEP Modularization Overview

**See WG10 STEP Modularization Team
Web Site
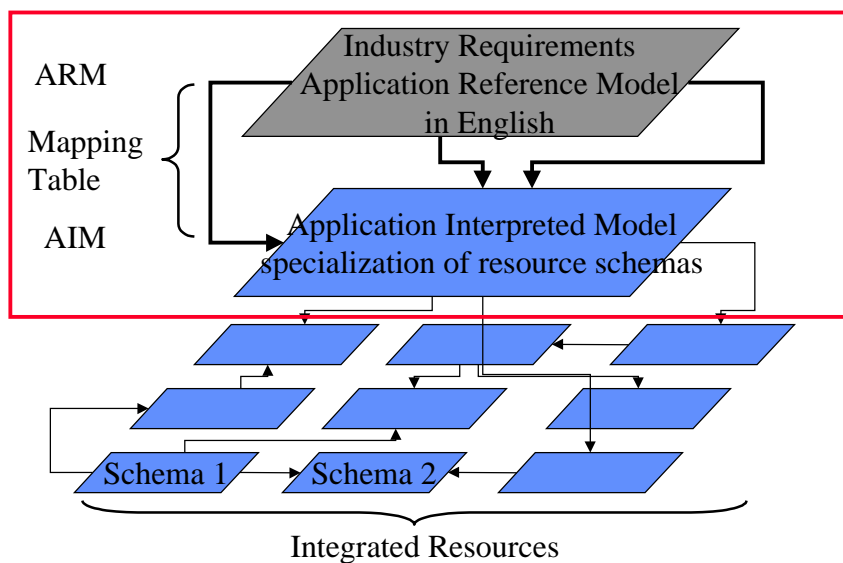http://wg10step.aticorp.org**

**David Price
IBM
October 2000
Charleston ISO
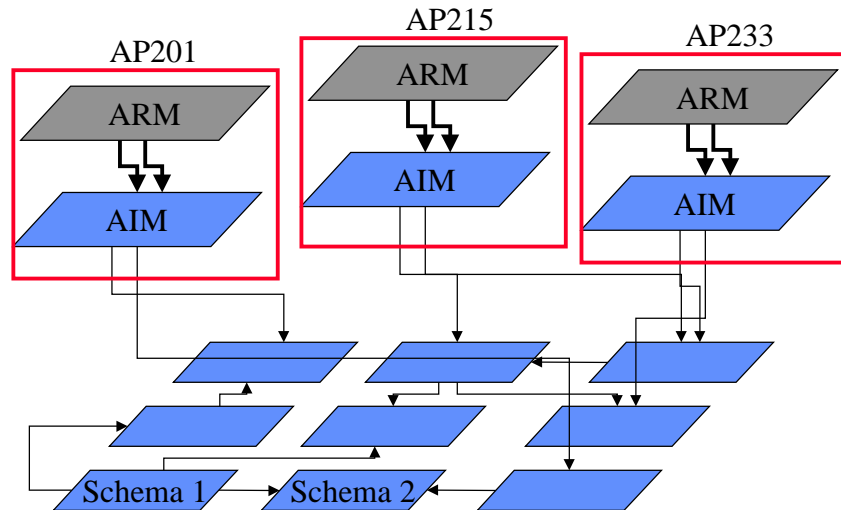dmprice@us.ibm.com**

Agenda

- **Brief review of modularity concept**
- **Current status of modular architecture project**
- **Overview of modules under development**
- **In-depth walk-through of some modules**
- **Issues**
- **Discussion**

Brief review of modularity concept

The Application Protocol

ARM

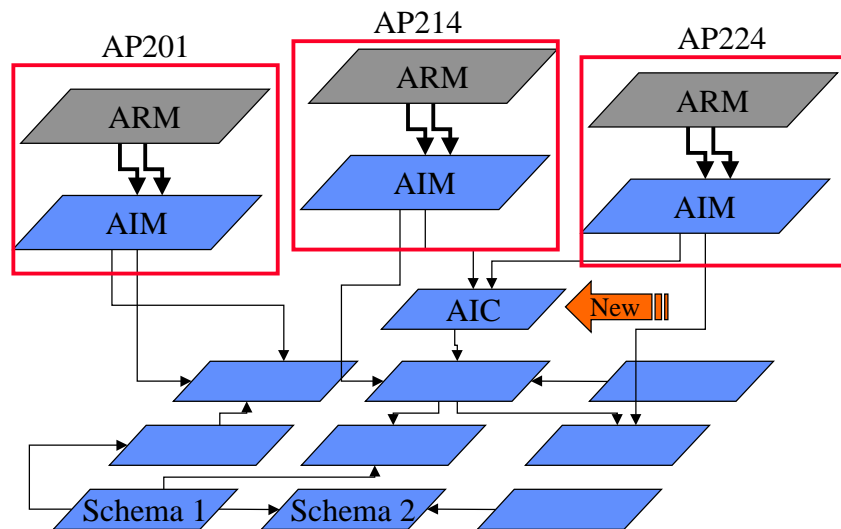Mapping
Table

AIM

Industry Requirements
Application Reference Model
in English

Application Interpreted Model
specialization of resource schemas

Schema 1

Schema 2

Integrated Resources

ISO
TC184/SC4

The 30 Application Protocols!

AP215

AP201

AP233

ARM

ARM

ARM

AIM

AIM

AIM

Schema 1

Schema 2

ISO
TC184/SC4

The APs

- **The approach**
  - **Each AP is scoped to be an "application"**
  - **Each AP is 300-3000 pages and is still not self-contained!**
  - **Every AP has overlaps with another AP**
  - **The "interpretation process" focused on the differences in applications, not the similarities or interoperability of applications**
- **Issues**
  - **Implementors expected to reuse code when capability overlapped**
  - **Users expected to share data when capability overlapped**

The Application Interpreted Construct - the first attempt at reusability

ISO
TC184/SC4

AP201

AP214

AP224

ARM

ARM

ARM

AIM

AIM

AIM

AIC

New

Schema 1

Schema 2

ISO
TC184/SC4

Issues - The AICs

- **The approach**
  - **AIC - a reusable resource schema**
  - **No requirements or mappings were included in an AIC**
  - **Worked well for areas already well understood like geometry**

- **Issues**
  - **The process was that the AIC would be created only when the second AP came along - no planned reuse allowed**
  - **AP teams saw only cost and delay with little real benefit and so avoided "discovering" AICs whenever possible**

AP Interoperability - the second attempt at reuse

- **The approach**
  - **No change to the architecture, but a change to the process**
  - **Document the "interpretation process"**
  - **Change the "interpretation process" to focus on similarities, not differences**
  - **Write an "Interpretation Guideline" that will force people to consider and encode reusability**

- **Issue**
  - **The "interpretation process" is based in human understanding and humans make mistakes**

Major Requirements for STEP Modularization

- **Reduce cost and time of AP development**
- **Companies require combinations of or extensions to APs**
- **Vendors expect to reuse software**
- **Eliminate repeated documentation of the same requirements and solutions across APs**
- **AP Interoperability - the reuse of data created by an implemenation of one AP by an implemenation of another AP**

Terminology

- **Application Module (AM)**
  - **A data specification containing an ARM, Mapping and MIM**
- **Application Extension (AE)**
  - **A documented subset of an existing AP**
- **Modular AP**
  - **An AP built using the new architecture**
- **Extended AP**
  - **An AP that uses an AE to add capability**
- **Module Interpreted Model**
  - **An AIM for an AM**
- **Foundation Module**
  - **A kind of AM that is very generic and reusable**

Key Architecture Decisions

- **Use EXPRESS for the ARM**
  - **Enables mapping with EXPRESS-X**
  - **Allows software to verify the references between the network of ARMs**
- **A Modular AP contains no ARM-mapping-AIM, it references an AM**
  - **This makes the AP data specification reusable**
  - **This separates business use from the data specification**
  - **Allows separation of conformance classes (CCs) from the data specification, CCs are a set of AMs and are specified in the Modular AP**
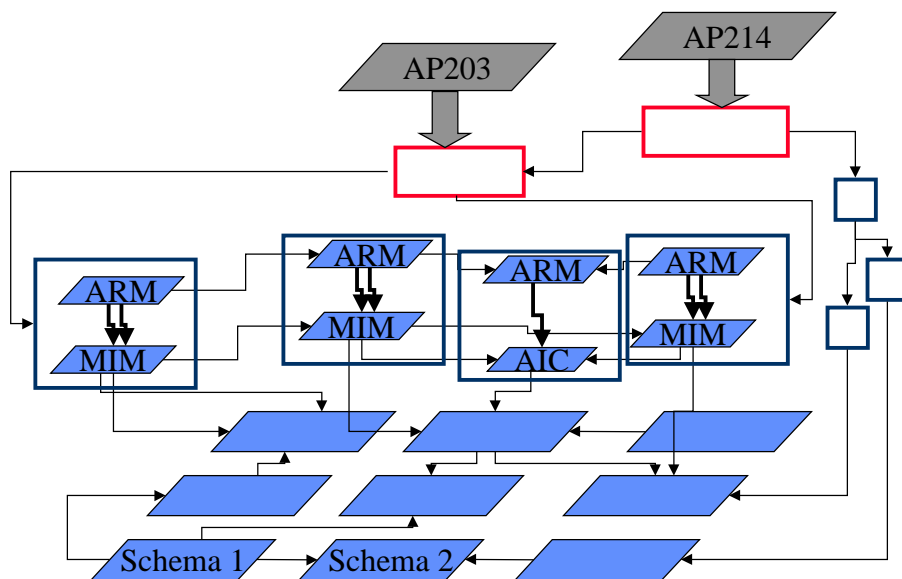
STEP Modularization

AP203

ARM

MIM

ARM

MIM

ARM

MIM

ARM

MIM

ARM

AIC

Schema 1   Schema 2
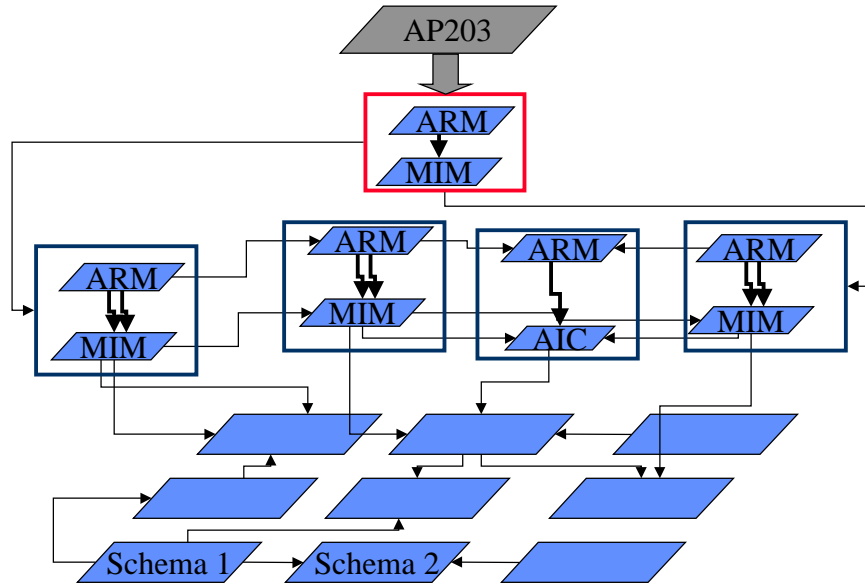
Key Architecture Decisions

- **AMs must be used in their entirety, always!**
    - **Modularization must support users, developers and implementors**
    - **Encourages more attention to scope by developers**
- **AM size, scope and domain is not prescribed**
    - **The architecture does not depend on this**
    - **Many considerations are important with respect to scope**
        - **IR structure**
        - **reuse by other developers**
        - **implementors**
        - **how capability is packaged in software systems**
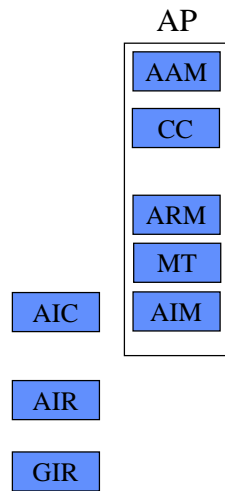
Key Architecture Decisions

- **Allow AE as migration path towards AM**
  - **These cannot be used for any new requirements**
- **Modularization is an "enabler"**
  - **There are many STEP/SC4 concerns that modularization may help**
  - **There are many STEP/SC4 concerns that modularization does not help**
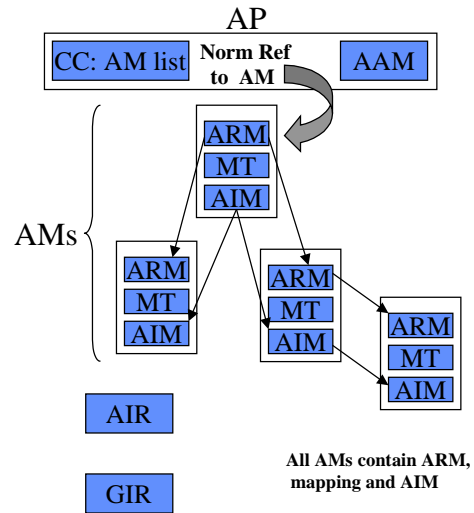

STEP Modularization - real reuse!

A Comparison of the Architectures

ISO
TC184/SC4

Current STEP Architecture

Modular STEP Architecture

AP

AP

| CC: AM list | **Norm Ref to AM** | AAM |

ARM
MT
AIM

AMs {

ARM
MT
AIM

ARM
MT
AIM

ARM
MT
AIM

AIC

AIR

AIR

GIR

GIR

All AMs contain ARM, mapping and AIM

Application Extension Architecture

ISO
TC184/SC4

AP1

AP2

AE

AP2 Edition 2

| AAM | AAM | Usage Guide | Combining Guide |

| CC | CC | **Norm Ref to ARM1 and MT1** | **Norm Ref to ARM2, MT2 and AE** |

| ARM1 | ARM2 | | |

| MT1 | MT2 | | |

| AIM1 | AIM2 | E | AIM2+E |
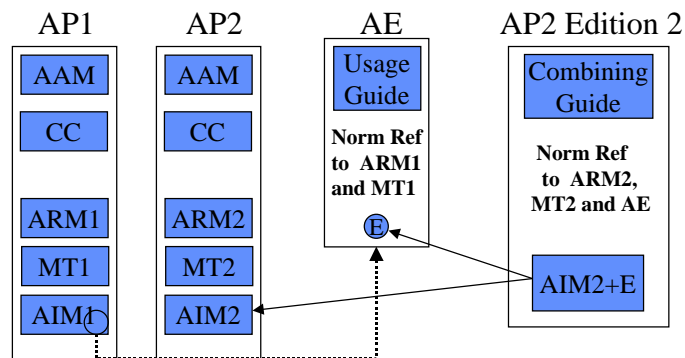
Identify and document AE subset of AP AIM

AEs do not contain ARM or mapping

AEs: A precursor to AMs

- **AEs are the reuse of a solution found in one or more APs in an extension to another AP**
- **Remodeling the requirements in the AE is not required**
- **AEs provide a good migration path from today's architecture to the future modularized architecture**
- **Extensions work - we already have experience in developing extensions and they have been implemented by vendors**
- **Compatible with and enforces AP Interoperability activities**
- **AEs are AMs with the following limitations:**
  - **Not necessarily reusable across many APs**
  - **Requirements documented by reference to an AP ARM**
  - **Not allowed for new development as we need an ARM to perform requirements analysis and mapping to constrain the MIM**

Kinds of APs

- **A modular AP is a documented use of an AM for a specific business process**
  - **A single AM is the data specification for the AP**
    - **The "big" AM uses other AMs and may add rules**
  - **Conformance classes are defined in the AP**
    - **Proposing allowing CCs to be selection of modules and/or rules**
  - **An Activity Model may be defined in the AP**
  - **Industry terminology mappings from generic AM terminology may be defined in an AP**
- **An extended AP is an AE applied to an existing AP**
  - **Limited scope and reuse**
  - **New or modified conformance classes allowed**

Current status of modular architecture project

The WG10 STEP Modularization PWI Kickoff

- **The PWI was initiated in June 1998**

- **Fundamental assumptions**

  1 - This project is addressing only the 10303 "AP architecture"

  2 - The new architecture is "an incremental improvement", not a "fundamental change"
    - **Retain the ARM, mapping, AIM, IR architecture**

  3 - With respect to documentation and standardization, less is more
    - **Standardize something once, and only once**
    - **Informative information should be readily available, but not necessarily standardized**

What's the PWI doing?

- **Developing the documents that describe the architecture**
- **Working closely with projects producing modules to get feedback**
- **Playing all support roles that the AP/AM teams need**
  - **Facilitating workshops**
  - **Being the "harmonization team"**
  - **Figuring out the standardization process**
  - **Providing quality reviews**
  - **Educating people on the approach**

First Deliverables

- **Guidelines**
  - **Guidelines for the Content of Application Modules**
  - **Guidelines for the Content of Application Protocols using Application Modules**
  - **Application Module Development Points within the Application Protocol Development Process**
- **Papers**
  - **Overview Paper and Presentation**
  - **STEP Modularization Requirements**
- **Infrastructure**
  - **Framework for AP/AM Categorization**
  - **AM Catalogue example/demonstrator**

ISO

Final Deliverables Additions

- **Samples**
  - **At least two example AM suites from different industries**
  - **An example modular AP**
- **Organization**
  - **Proposal to SC4 of any organizational/process changes**
  - **A series of seven "Impact papers"**
    - **Vendors, Users, IRs, Part 20s, EXPRESS, EXPRESS-X, Data Architecture**
- **Guidelines**
  - **Recommended Practices for AM Development**
  - **An update to ISO 10303-1**

ISO

Accomplishments Since Bordeaux

- **STEP Modularization Strategy**
  - **WG10 review draft of STEP/SC4 Industrial Data Framework delivered**
  - **NIST Modules Repository DTD review**
  - **September workshop in Winter Park**
    - **Reviewed and resolved issues on**
      - **Guidelines for application modules content**
      - **Guidelines for modularized application protocol content**
      - **Module development points within the AP development process**
  - **Produced WG10 review document for:**
    - **Guidelines for modularized application protocol content**

Winter Park Workshop Agenda

- **Where we are**
  - Bordeaux SC4 Modularization Resolution
  - Review of Deliverables
  - Planned Fall Deliverables
- **Review and update of AM Content Guidelines**
- **Review and update of Modular AP Content Guidelines**
- **Review and update of AP/AM Development Process Guidelines**
  - Grouping HTML modules for ballot

Bordeaux SC4 Resolution

- **"STEP Modules Harmonization Team" is planned**
- **"SC4 resolves to establish this team prior to the next meeting in Charleston, and directs them to commence work upon completion of the necessary guidelines by the PWI (see resolution 374)."**
- **"SC4 directs the PWI to complete the guidelines and submit them for standing document ballot no later than 2000-10-30."**

ISO

Winter Park Guidelines Deliverables Details

- **Guidelines for the content of application modules**
  - No change since Revision 0.6 N221 dated 1998-12-23
  - Some updates based on DTS should me made
- **Application Module Development Points within the Application Protocol Development Process**
  - No change since Revision 0.2 N223 dated 1999-01-21
- **Guidelines for the content of application protocols using application modules**
  - No change since Revision 0.6 N222 dated 1998-12-21

ISO

Winter Park Workshop Results

- **Pending completion of editorial work, send each document to 4-week WG10 review followed by SC4 Standing Document ballot**
- **On STEP Modularization "Packaging Issue" WG10, if necessary will submit a resolution in Charleston**
  - It appears this may not be necessary, we've checked with ISO and packages are allowed
  - SC4 Secretariat will include cover letter explaining the "package ballot"
  - The 40-50 modules will be balloted as 7-8 packages with a single Yes/No vote on each package
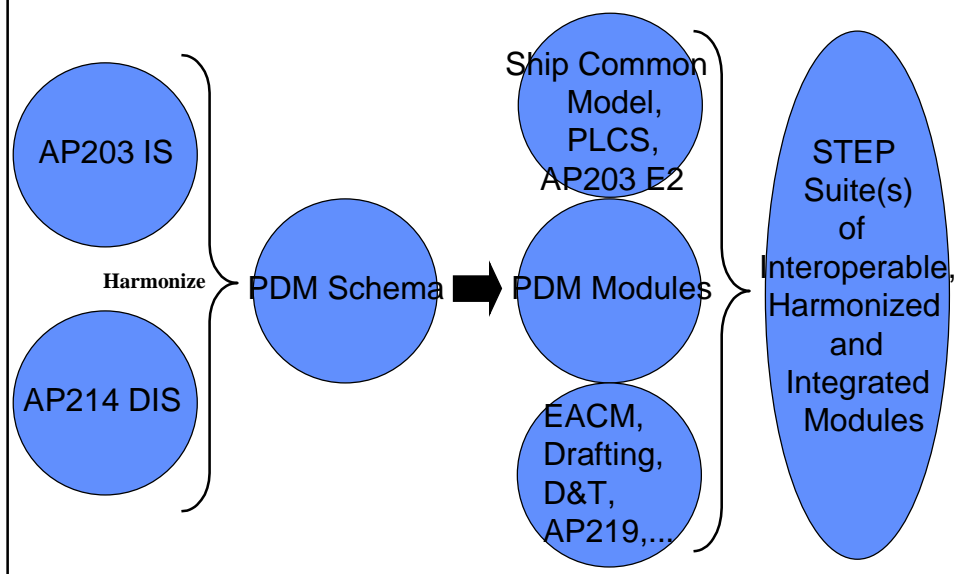
PWI Next Plans

- **Supporting NIST Modules Repository**
- **Complete Guidelines documents for WG10 review and SC4 ballot**
  - **modules content**
  - **development process**
  - **modularized AP content**
    - **already out for WG10 review**
- **Support PDM modules ballot**
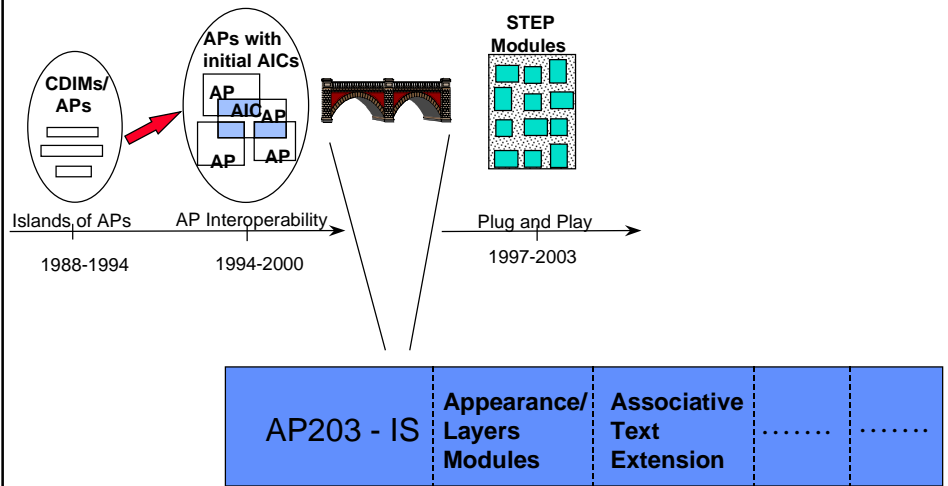
Overview of modules under development

Early adoption of modularization

- **The following "nominated" projects are producing modules now**
  - Shape appearance and layers modules suite
  - PDM modules suite
  - EACM modules suite
- **WG10 support includes**
  - Harmonization workshop facilitation
    - Each project has attended the interim WG10 workshops
  - Technical, standardization and quality review help
  - Categorization using framework
  - Inclusion in modules catalogue and repository

One planned use of the Modularization Strategy

A second planned use...

STEP Modules

APs with initial AICs

CDIMs/ APs

AP
AIC AP
AP   AP

Islands of APs — AP Interoperability — Plug and Play

1988-1994 — 1994-2000 — 1997-2003

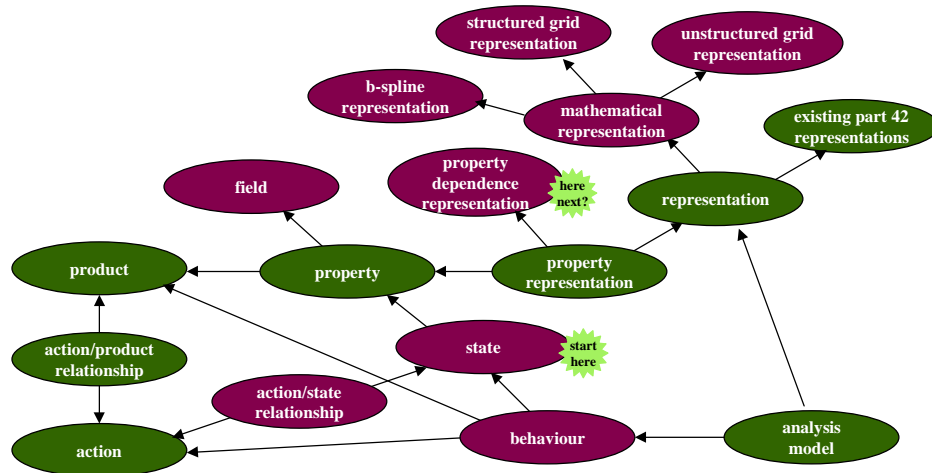| AP203 - IS	Appearance/ Layers Modules	Associative Text Extension	. . . .	. . . .

A third planned use ...

Module for state

David Leal

CAESAR Systems Limited

david@cedarlon.demon.co.uk
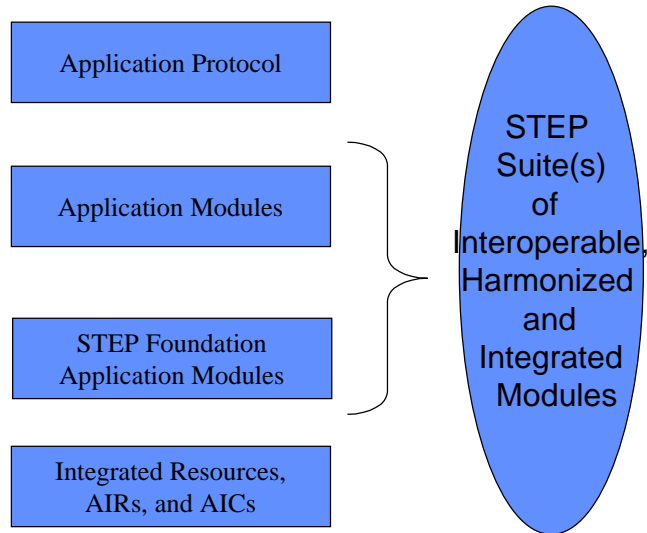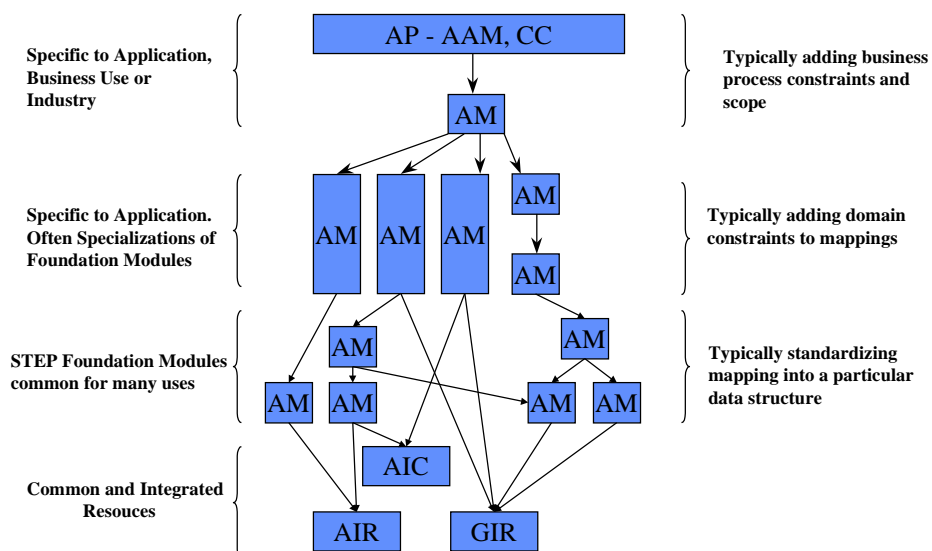
Modules for engineering analysis

There are different kinds of modules

- **The idea of "foundation modules" has surfaced during workshops held with development teams**

- **The idea is simple - There should be very generic modules (both the ARM and AIM are generic) that are easily reusable**

- **Most AP development would be specialization and constraint of these modules (hopefully)**

Foundation modules and the AP architecture

Application Protocol

Application Modules

STEP Foundation Application Modules

Integrated Resources, AIRs, and AICs

STEP Suite(s) of Interoperable, Harmonized and Integrated Modules

---

Foundation modules and the AP architecture - details

Specific to Application, Business Use or Industry

AP - AAM, CC

AM

Typically adding business process constraints and scope

Specific to Application. Often Specializations of Foundation Modules

AM AM AM

AM

AM

Typically adding domain constraints to mappings

STEP Foundation Modules common for many uses

AM

AM AM

AM

AM AM

Typically standardizing mapping into a particular data structure

Common and Integrated Resouces

AIC

AIR GIR

Foundation Module "Plans"

Classification

Alias Identification

Software

Function

Part

Document

AP209, EA, AP233, EMSI, Systems Engineering Modules

Product Identification, Categorisation, Version, Structure, View Definition

Management Stuff Person, Organisation, Change Management Approval, Date Time, Contract, Security Classification, Project

AP203, AP214, Configuration Management Modules

AP232, Technical Data Packaging Modules

Product Properties

PLCS, AP208 Modules

File Identification, Properties

Property Representation

Shipbuilding Modules

AP214, AP224, AL210, GD&T

Property Presentation

Shape, Geometry, Geometric Structure, Solid Model History

AP224, AP214, Mfg Features

Appearance, Color, Layer

AP202, AP214, Drafting

Summary and Conclusions

Building a modular AP?

- **The technical work necessary to build a modular AP is finished**
  - **Some paperwork remains to be completed**
  - **Some formal support organization issues remain**
    - **At the moment, the WG10 STEP Modularization PWI is the support organization**
  - **Some infrastructure work remains if you want to use XML or HTML**
    - **If you want to produce paper standards, you can get started**
- **There are significant modular AP projects already underway**

Ballots Are Coming!

- **The guidelines Standing Document ballot will happen this Fall**
- **The PDM modules "packages" Preliminary Draft Technical Specification ballot will happen this Fall**
- **Please participate - now is the time to get your concerns addressed in a formal process**

Module
Development

Rogerio Barra

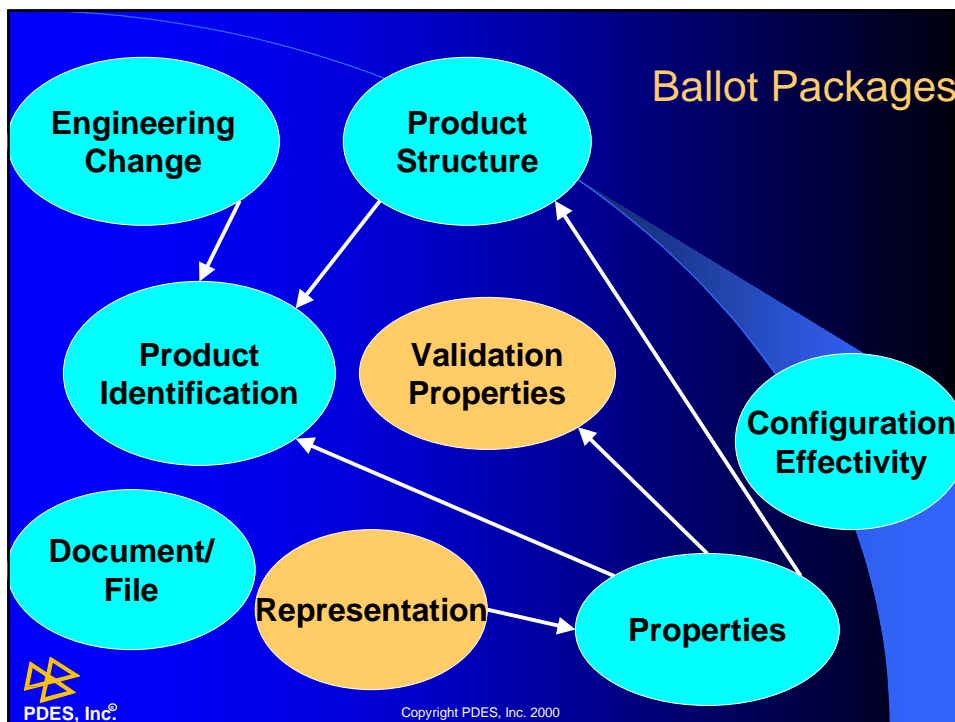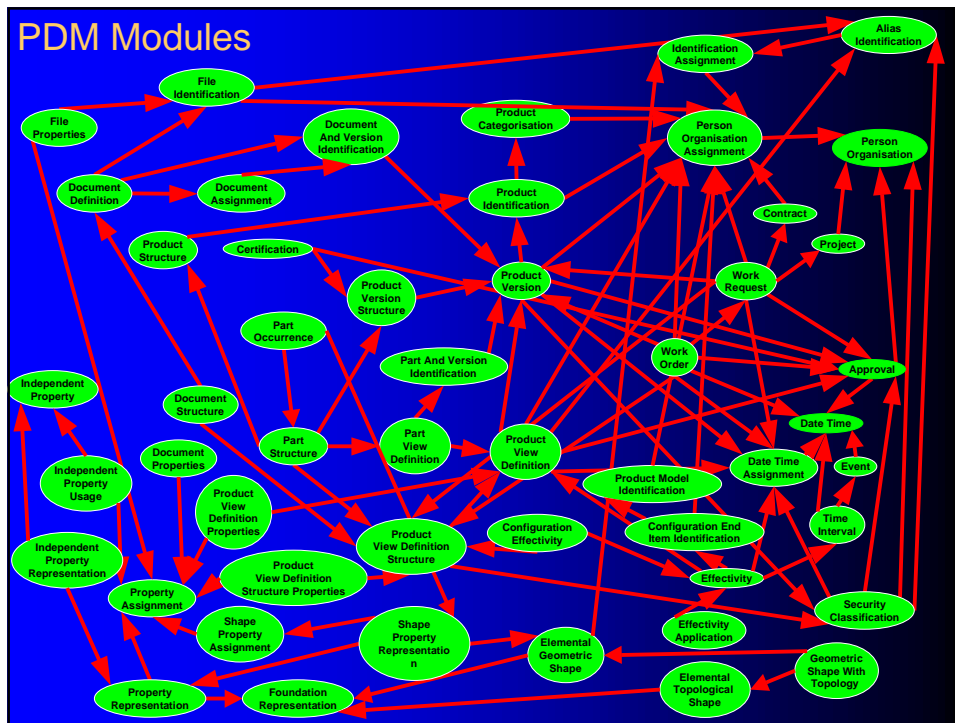### October 10, 2000

Module Development
Objectives

- Develop and validate module suites for
  - PDM
  - Solid model construction history
  - Engineering analysis
  - Systems engineering
  - Also support ongoing work in drafting and dimensional tolerances
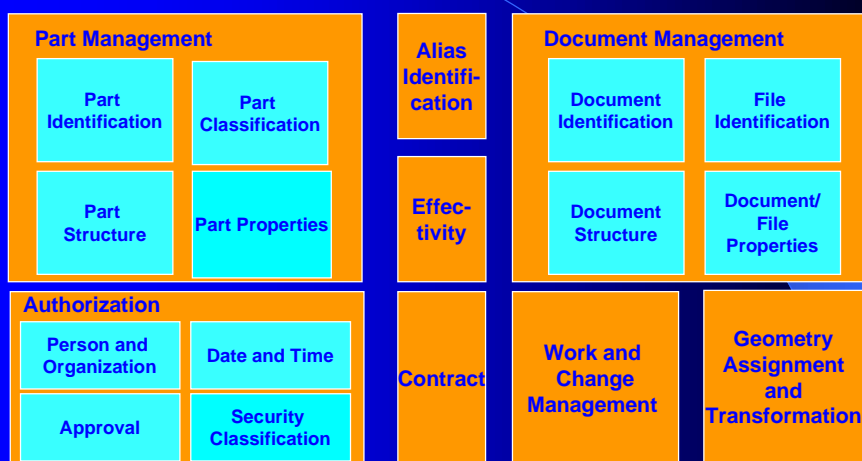
Product Data Management

Recent Accomplishments

- Coordinated with AP214 team on resolution of interoperability issues related to rules
- Issued three updates to the PDM modules
- Drafted AP203 Amendment 1 and sent to ISO for a two month ballot
  - Fixes EXPRESS errors in AP203 and incorporates EXPRESS Technical Corrigenda corrections to Parts 41,42, 43, and 44
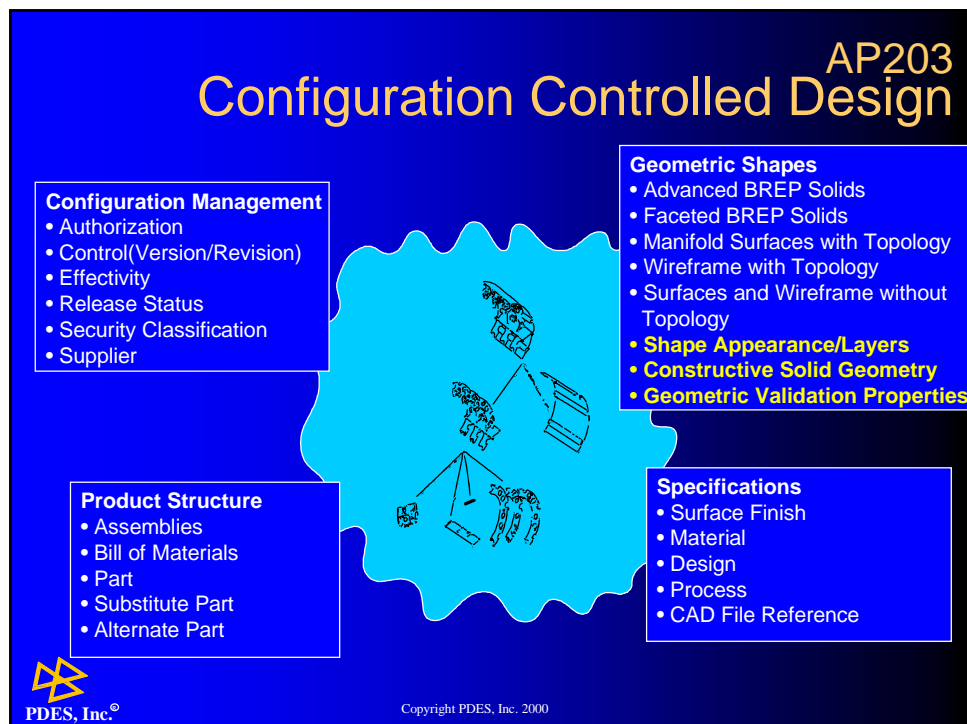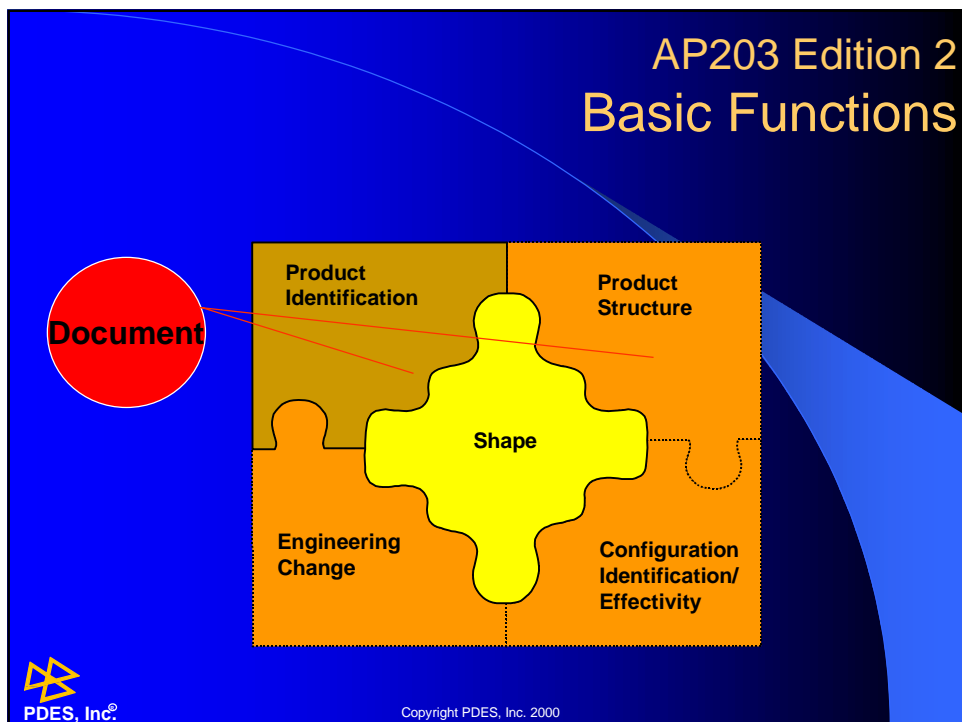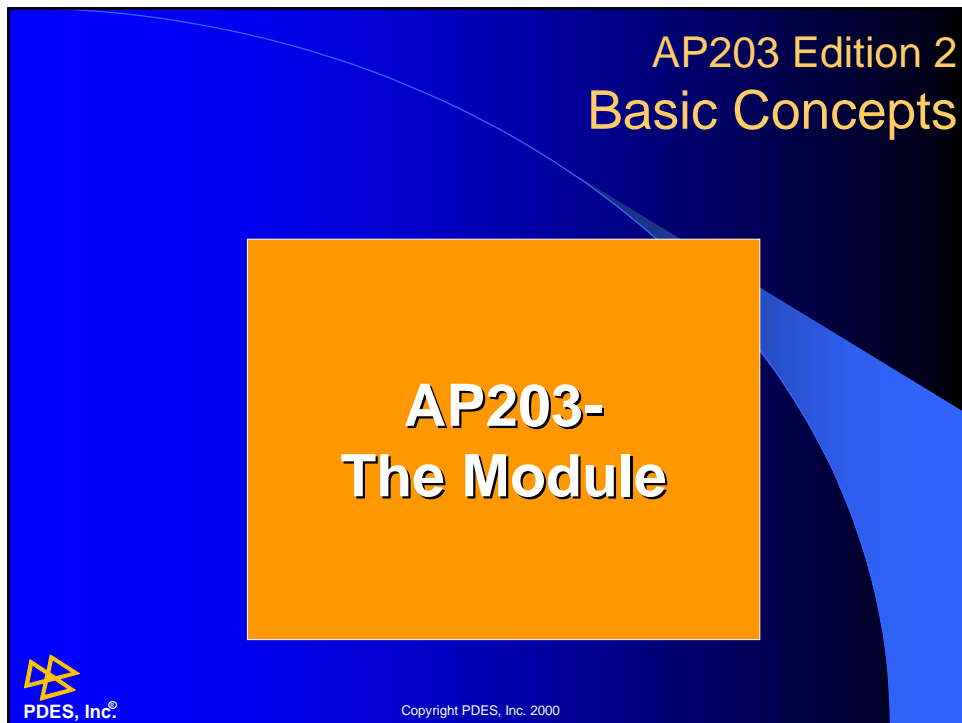
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PDM Modules

Ballot Packages

Backup Slides

Scope of the PDM Schema

Part Management

Part Identification	Part Classification
Part Structure	Part Properties

Authorization

Person and Organization	Date and Time
Approval	Security Classification

Alias Identifi-cation

Effec-tivity

Contract

Document Management

Document Identification	File Identification
Document Structure	Document/ File Properties

Work and Change Management

Geometry Assignment and Transformation

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AP203 Edition 2
Configuration Controlled Design

Configuration Controlled Design

Configuration Management
- Authorization
- Control(Version/Revision)
- Effectivity
- Release Status
- Security Classification
- Supplier

Geometric Shapes
- Advanced BREP Solids
- Faceted BREP Solids
- Manifold Surfaces with Topology
- Wireframe with Topology
- Surfaces and Wireframe without Topology
- **Shape Appearance/Layers**
- **Constructive Solid Geometry**
- **Geometric Validation Properties**

Product Structure
- Assemblies
- Bill of Materials
- Part
- Substitute Part
- Alternate Part

Specifications
- Surface Finish
- Material
- Design
- Process
- CAD File Reference

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Shape/Extended Functions
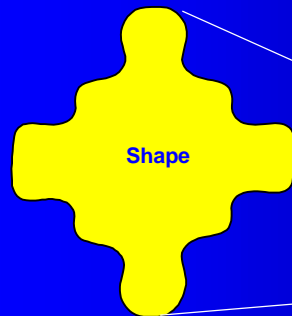
Shape

| Advanced BREP |
| Faceted BREP |
| Constructive Solid Geometry |
| Manifold Surface |
| Topologically Bounded Wireframe |
| Geometrically Bounded Wireframe |

Shape Appearance and Layers

Geometric Validation Properties

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AP203 E2
Conformance Classes

- Currently 203:1994 has 12 classes (2-PDM and 5 Shape)
- AP203:2000 will also have 12:
  - Product Identification (~ 203 CC1a)
  - Product Structure
  - Engineering Change
  - Configuration Identification/Effectivity
  - Shape
    - Advanced BREP Solids
    - Faceted BREP Solids
    - Manifold Surfaces with Topology

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Conformance Classes (cont.)

- – Shape (cont.)
    - Wireframe with Topology
    - Surfaces and Wireframe without Topology
    - Constructive Solid Geometry
- – Color/Layer
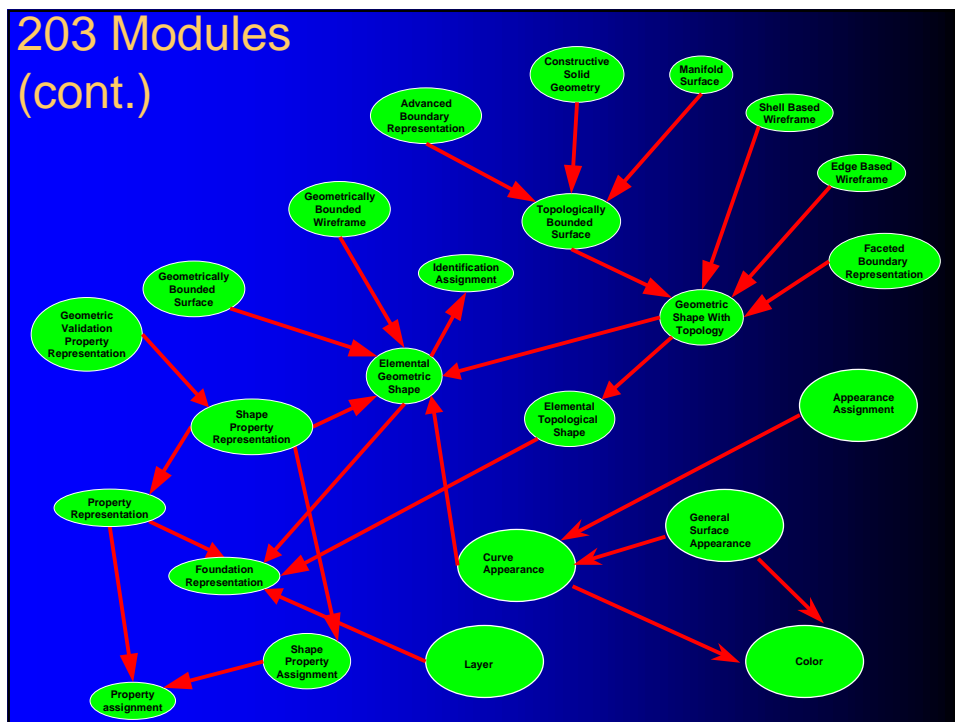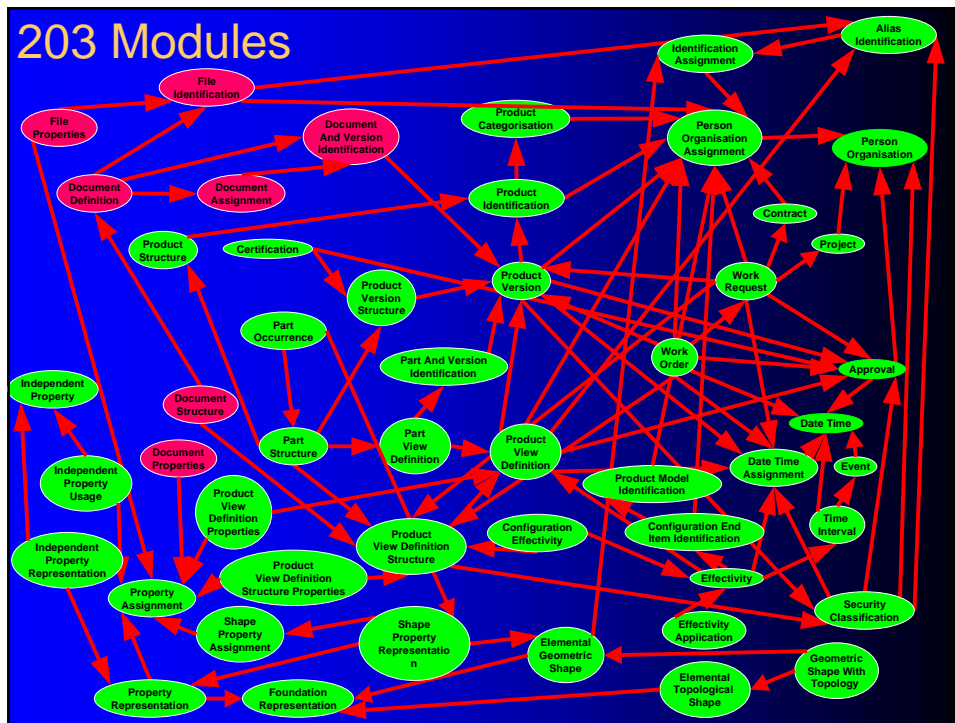- – Geometric Validation Properties
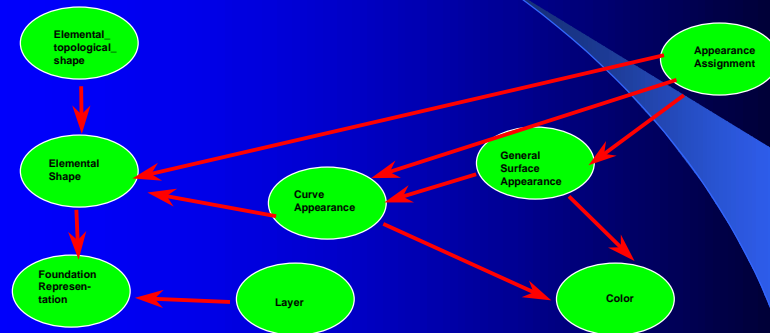- New ones are based on functionality

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Back-Up Slides

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Module Development 8

203 Modules

203 Modules (cont.)

Elemental_
topological_
shape

Appearance
Assignment

Elemental
Shape

Curve
Appearance

General
Surface
Appearance

Foundation
Represen-
tation

Layer

Color

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Geometric Dimensioning and Tolerancing (GDT)

Module Development

Objectives

- Develop and validate modules for geometric and dimensional tolerances

- Support CAD vendors implementing the modules

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Recent Accomplishments

- Developed two drafts of PDM Properties
- Developed draft GDT suite in PDES, Inc. html format
  - Harmonized with ISO
- Developed experimental scripts for data-driven module authoring
  - "one click" html authoring

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GDT
Plans

- Develop GT usage guide for vendors
- Develop annotation/presentation module suite
  - Based on AP214
  - Harmonized with Model Viewing
- Pursue validation of GDT modules
- Harmonize DT modules with FDIS AP214
- Republish GDT modules as html
- Prepare PDM Properties modules for ISO ballot

AP233
Systems Engineering

AP233 Systems Engineering
Objectives

- Prepare for general release and review:
  - AP233 Requirements Document
  - AP233 ARM document
- Modularize and harmonize information model across PDES, Inc., INCOSE, PLCS interest groups
- Establish clean interface between Systems Engineering and the Engineering Support Domains serviced by STEP APs

AP233 Systems Engineering
Recent Accomplishments

- INCOSE review of AP233 at NASA/JPL in May
  - Very positive comments, major contributions made
  - Response to INCOSE developed at June ISO meeting
- Requirements Document
  - Waiting for INCOSE comments to be inserted

AP233 Systems Engineering
Recent Accomplishments (cont.)

- ARM
  - INCOSE recommendations - nearly all accepted
  - Decision to move towards modularization made
  - PDES, Inc./SEDRES modularization meeting in UK
  - Conclusion - No show stoppers, but SEDRES team will need help
- ARM - extensions to support PDES, Inc. needs
  - AP233 linkages to CAD/CAM/CAE SE support capabilities; et. al.
  - How? Who? Discussed at Offsite

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AP233 Systems Engineering
Plans

- Support modularization
- Support need for AP233 extensions that provide:
  - Links to CAD/CAM/CAE STEP supported APs
  - Traceability of associated system requirements
  - Links to Technical Data Packaging to support a SEs need to make, reuse, restart or redo test & analysis decisions
- Support need to define PDES, Inc. Systems Engineering pilot project

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Module Development

Engineering Analysis

Engineering Analysis
Recent Accomplishments

- Draft Part 5x 'Mathematical Description'
  - Links Part 50 to the rest of STEP
  - Reviewed in Bordeaux
  - Harmonised with Parts 43 and 108
  - Issued as WG12 N605
- EACM (Engineering Analysis Core Model) module progress
  - Concept of state harmonized with AP233
  - Interpreted on to Part 50 DIS and draft Part 5x
  - Initial documents ready for review

Engineering Analysis
Plans

- Submit first batch of EACM modules for TS ballot

- Conduct simultaneous NWI/CD ballot for Part 5x

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Solid Model
Construction History

Solid Model Construction History
Objectives

- To develop modular capabilities to exchange history based parametric features and constraints to enable the modification or editing of a design model in a receiving system

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Solid Model Construction History
Recent Accomplishments

- Published Feature-Based Construction Operations document addressing Priority 1 list through Blends (see next slide)
- Developed draft Implementors' guide that includes integrated model, test part, and Part 21 file

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Solid Model Construction History
Recent Accomplishments (cont.)

- Priority 1 List
  - Linear sweeps of sketch (extrusion)
  - Rotational sweep of sketch
  - Boolean operations (union, diff., intersect.)
  - Blending (including rounding, filleting, etc.)
  - Rigid body transformation (translate, rotate)
  - Generation of feature patterns
  - Use of system defined features from a library

Solid Model Construction History
Recent Accomplishments (cont.)

- Construction history model is an integrated model using these resource structures
  - Part 108 - Parameterization and constraints for explicit geometric product models (SC4/WG12 N526)
  - Parametric framework for exchange of geometric product models (SC4/WG12 N441)
  - Feature-Based Construction Operations (SC4/WG12 N 589)

Solid Model Construction History
Recent Accomplishments (cont.)

- Held successful workshop at ISO Meeting in Bordeaux (June 29-30)
  - Published draft Implementors' Guide as key workshop material
  - About 15 participants at workshop (vendors included Dassault, Spatial, Unisys, GSSI)
- Work underway to incorporate workshop feedback

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Solid Model Construction History
Plans

- Continue to work with ProSTEP on joint work plan and implementation effort
- Publish Implementors' Guide incorporating workshop decisions
- Conduct workshop at October ISO Meeting in Charleston
- Obtain vendor commitments to begin implementations as part of CAx-IF Round 5J

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Module Development